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TITLE OF INVESTIGATION: Population Ecology of Arctic Land Vertebrates

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CONTENTS

OBJECTIVES

The chief objective of the research supported by this contract and carried out primarily at the Arctic Research Laboratory was to study natural populations of arctic birds and mammals, first, with respect to characteristics of their population structure and, second, with respect to factors affecting fluctuations of populations and their general welfare.

This is a broad statement, intended to relate our efforts to the gamut of modern research in biology. In the arctic, studies of population ecology are still largely exploratory, and for this reason our approach was extensive and comparative. As subjects for our studies, several common species of birds and the only common mammals (lemmings) were chosen, and we collected information on a series of specific problems, to be enumerated below, already more or less explored at mid-latitudes but requiring attention in the arctic because of the special conditions obtaining there. The results are a contribution toward a basic problem of biology, that is, the problem of nature of adaptations of animals, in particular their behavior and population organization, in relation to the arctic environment.

The separate sections of our program may now be listed and summarized briefly. But it must be emphasized that collections of data and specimens are the result of eleven man-summers of concentrated work. There are hundreds of pages of records on file that have yet to be summarized, analyzed, and written up for publication. Hence, what results or conclusions are suggested in the following sections must, with respect to specific detail, be regarded as tentative. It will take a number of years properly to conclude the publication phase of our three years of field work. The only sections adequately summarized are that on avian predators (see V) and part of that dealing with insects (see VI). On these subjects, several papers are ready for publication.

SUMMARIES BY SECTIONS

I

BREEDING SEASONS OF BIRDS

Problem

The ability of small arctic birds to survive as species at high latitudes is dependent on their adaptations to the rigorously limited time available for breeding and related events. First, then, what is the timing of breeding in small arctic birds, assessed on a population basis?

For information toward this problem, the three commonest species of small birds were selected for close study. These are the Lapland Longspur, Snow Bunting, and Red Phalarope. Records from nests and from collected specimens give data on clutch size, on period of egg-laying, on length of breeding cycle, on incidence of late or second nestings, and on the role of time factors in the performance of the population. The last point is elucidated by differences between seasons and by differences in the outcomes of early versus late nestings in any one season.

Results

1) The breeding cycle of the longspur and bunting takes 30-35 days. In this respect, small finches at high latitudes do not differ from those at mid-latitudes.
2) Breeding in small passerines is timed to begin abruptly with the rapid exposure of the tundra in the course of the first half of June so that easily 80 to 90 per cent of each population begins its breeding within a week or less.
3) There is therefore a remarkable synchrony in the inception of breeding. The significance of this fact is better understood when it is related to events in the latter part of the summer (see section IV).
4) In a fraction of the population, nestings are started in late June, or even early July, usually because first attempts were unsuccessful.

In some instances (known only for the longspur), bona fide second nestings may be started (that is, nestings started after first nestings were concluded satisfactorily). Near Barrow, any late nesting is doomed because of complications resulting from molt (see below).

5) Clutch size in 1951 was 5 plus (4-6) for the longspur, 6 plus (4-7) for the bunting. There is some indication that average clutch size fell in 1953, when vegetation was extensively grazed back by lemmings and the supply of insect food was reduced (see section VI).

6) In the shore-bird studied (the Red Phalarope), clutch size is 4, occasionally 3. Breeding begins later, takes longer, and does not necessarily begin with the degree of population coordination seen in the passerines. This is permitted, so to speak, by two important features in the annual cycle in this and other shorebirds:

   (a) In some species (including the phalarope), one sex leaves the breeding grounds before the other which attends the young, thus leaving for the young more of the waning late-summer food resources tapped by the given species.

   (b) The molt occurs, in the main, away from the breeding grounds so that this energy-demanding process does not strain directly the balance between requirements for breeding and local food resources.

II

LOCAL DISTRIBUTION OF BIRDS

Problem

It was necessary to acquire some picture of relative numbers, and also of inflow and outflow, in the local populations of the three species of birds studied closely. Attempts to gather this information also yielded data on another important matter, which is population organization of the species. By this we refer to the pattern of local spacing of breeding birds, their territoriality, the stability of the pair as a breeding unit, the incidence of extra males or females, and so forth.

Data were gathered in three ways:

(1) By recording daily, in notebooks kept individually by all members of the research team, observations concerning arrivals, local variation in numbers, local movements, flocking, breeding territories, departure and any other phenomena contributing to an understanding of local distribution. This is of course a big order, and we did as much as time and energy stores allowed, always stressing the few species which were abundant and of special interest to us.

(2) By banding and retrapping of the two seed-eating finches, the longspur and bunting, and incidentally also various other species.

(3) By color-banding of breeding buntings and longspurs.

Results

1) In the course of the three seasons of work, 2918 birds were banded. A list of species banded is given in appendix 1. (Bands were provided by the Fish and Wildlife Service, and reports of our results were filed annually with the offices of this agency in Juneau and Washington.)

2) Through banding activities, there were accumulated several thousand

records of banded birds repeating in traps in each of the three seasons and several hundred of birds returning in subsequent years.

3) Other records gathered and mentioned above, as well as those just declared under (1) and (2), have yet to be summarized and analyzed. These will comprise the basic source of data on local movements, on quantitative shifts in the local population, on sex ratios, on age ratios, and other matters.

III

BIRD POPULATIONS

Problem

The understanding of the over-all performance of a bird population in the arctic requires knowledge of its local breeding density as an index to reproductive capacity along with the items mentioned above (sections I and II). To obtain such data for two of the common species (longspur and phalarope), three plots were laid out in 1951 in contrasting sections of the tundra:

(1) 40 acres along a beach ridge representing relatively well-drained tundra.

(2) 20 acres on a flat area with low-center polygons and ponds, representing a poorly drained area of varied microtopography.

(3) 86 acres on a wet marsh flat.

While the longspur and phalarope were of primary interest, these plots were censused for total populations.

Results

The data have yet to be summarized. Some wide differences occurred and reflect the year-to-year variation which normally occurs in the arctic. Particularly striking is the variation in numbers of

avian predators and waterfowl in 1953 as against the previous two summers. For example, brant and pintails, and also short-eared owls, bred abundantly in 1953, but were absent in the same areas in 1951 and 1952 except for one or two records of the pintail. Some small species also show striking variation: the redpoll, common in 1952, was rare in 1951 and 1953. Otherwise, differences between seasons in populations of the smaller and more common species were small and further comment must be delayed until after the data are summarized and analyzed.

IV

MOLT IN PASSERINE BIRDS

Problem

Within the available summer period at 71° N. latitude, such passerine birds as the bunting and longspur both breed and molt, and these activities must be concluded successfully, at least for the population as a whole, if each species is to continue as a regular member of the fauna so far north. The annual molt involves the complete replacement of all feathers, and this proceeds in a systematic and easily measurable fashion.

The main questions, then, are these: At 71° N. latitude, what period of time is required for molt, what variation occurs within each population, and what rates of molt are displayed by these high arctic species?

On the basis of available knowledge concerning the molt of passerine birds, a new system of recording quickly the molt stage of each individual at any given time was devised in 1951. By this method dozens and even hundreds of birds handled in one day in the course of trapping procedures could be read quickly and the progress of molt could be measured for successive intervals of time spanning the entire period

required by molt. This was done for the whole of the molt periods in 1951 and 1952 and for the beginning of it in 1953.

In addition, brief experiments were performed in an attempt to disrupt the timing of molt by manipulation of light schedules. These were purely exploratory.

Results

1) Molt of the longspur and buntings begins in the first half of July, earlier in the former than the latter. It also begins abruptly in the whole population, more so in the longspur than in the bunting. Molt takes approximately 50 days. It is completed, or virtually completed, before fall migration begins.

2) Molt and breeding do not overlap widely on a population basis and little, if at all, on an individual basis. As molt is virtually completed on the breeding grounds, the molt process must be accommodated within the short summer period along with breeding. Hence the abrupt beginning and high degree of synchrony in both breeding and molt. There is no leeway permissable in the responsiveness of the individual to stimuli which initiate molt. Delays inevitably expose the bird to dropping temperatures and decreasing food supplies in late August when it must accumulate fat stores before undertaking migration. These facts describe what is probably the chief population adaptation, and a dramatic one, which small passerines must make in the arctic to survive the rigors of that environment.

3) Molt period of these far northern birds is not necessarily shorter than in those of temperate latitudes, but it begins earlier. Moreover, within the population as a whole, there is a synchrony of molt stages so that the time taken by molt in the population does not greatly exceed the time taken by molt in the individual. In general this differential becomes successively greater along a gradient from

the arctic to the tropics.

4) Two experiments were performed on molt:

   a) At Barrow a small group of birds was subjected to periods of darkness in advance of the time molt normally begins (at which time, also, the summer light is continuous).

   b) At Berkeley, California, a group of birds brought from Barrow was kept through the winter of 1952-53 so that for this group, the spring and summer schedule of alternating light and dark did not evolve into the continuous light occurring at the Barrow latitude.

Both groups of birds began their molt at about the same time that is normal for the species near Barrow. This suggests a genetically fixed timing mechanism for molt in the Snow Bunting. (Birds vary as to the degree this process can be manipulated experimentally. The significance of this preliminary finding on the Snow Bunting must be checked by further experimentation and by comparable study of other high-latitude species.)

V

BIOLOGY OF LEMMINGS AND THEIR PREDATORS

<u>Problem</u>

Questions concerning the biology of lemmings and their fluctuations comprise a many-faceted problem which is central in the population ecology of arctic lands. We merely collected data on three basic points

(1) Structure of the lemming population in 1952 and 1953 as revealed by mass samples taken at 10-day intervals.

(2) Relative numbers and breeding densities of avian predators, all of which were dependent on lemmings.

(3) Prey of Snowy Owls as revealed by examination of pellets.

Through the summer of 1952 and 1953 when lemmings were abundant, large samples (usually 100 to 200 each) were collected with the help of eskimos at 10-day intervals. These were examined in the laboratory and data on size, weight, sex, and condition of gonads were taken. This phase of our program was carried out in cooperation with Dr. Robert Rausch of the Arctic Health Research Center, Anchorage, Alaska. Specimens obtained by us were also used by him for the special needs of that agency.

In 1952 and 1953, on areas of 9 and 7 square miles, respectively, a census of avian predators was carried out. The important ones, as nesting species, are the Pomarine Jaeger, the Snowy Owl, and the Short-eared Owl.

Large numbers of pellets were collected each summer. These have been washed and their contents classified in the course of the winter seasons 1952-53 and 1953-54. Mammal remains have been identified, but the bird remains, representing at least a dozen species, have yet to be studied.

<u>Results</u>

1) The main growth of the lemming population, in the upswing phase of the cycle, occurs in the winter period. This was clearly shown by composition of samples and local densities early in the seasons of 1952 and 1953 as compared with the previous autumns, respectively. (The previous crash in the lemming population had occurred in spring, 1949; lemmings were scant in 1950 and 1951. The crash of the present cycle is expected in the winter of 1953-54.)
2) Reproductive rate was low or zero at the beginning of the summer season, but pregnancy rates climbed quickly as snow melt-off proceeded, with young of the summer generation coming above ground in mid-July.

3) In both summers, numbers of lemmings dropped as a result of predation but the population recovered only partially prior to September and not until the young of the summer generation appeared. Hence the potential for increase was only partly, although still conspicuously, realized with the summer generation.

4) By the end of each summer, reproductive activity was less than earlier.

5) By the end of the summer, some of the summer-born lemmings had produced young of the fall generation in 1952, but there was no sign of this in the lemmings examined in 1953.

6) Sex ratio fell through the summer of 1952, indicating greater rate of mortality in males than females. This evidence, from specimens examined, has been confirmed by data on the contents of pellets as well as by composition of prey accumulated at a Snowy Owl's nest. That is, the rate of mortality in males, in summer, is higher than in females; and this results from a greater take of males by predators.

7) Nesting of avian predators did not occur in 1951. In 1952 and 1953, nesting density of jaegers averaged 4 and 18 pairs per square mile. Snowy Owls were also more numerous in 1953 than in 1952, but breeding densities were about the same (one pair per 2-4 square miles). Short-eared Owls, absent in 1952, bred commonly in 1953, reaching a density at least locally of 7 pairs per square mile.

8) At the time of a lemming peak, better than 99 per cent of the food of the Snowy Owl is the brown lemming (Lemmus trimucronatus).

VI

INSECT POPULATIONS

Problem

Because of the relationship between breeding and molt brought out above (section IV), most breeding actually is compressed into the

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VI

INSECT POPULATIONS

Problem

Because of the relationship between breeding and molt brought out above (section IV), most breeding actually is compressed into the

first month of the summer. The question arose, after the 1951 experience, whether the relationship between peak breeding activity in birds and peak abundance in food, as known for southern latitudes, would or even could apply to arctic latitudes.

To provide data on this point, the seasonal changes in insect populations were studied by Dr. Paul D. Hurd of the Department of Entomology, University of California, Berkeley. Field plots were established in early summer, 1952, and studied through that season and also through 1953. Surface counts and samples of surface-soil invertebrates (Berlese method) were taken at 5-day intervals providing data which serve as an index to the seasonal changes in, and the relative productivity of, three different habitats.

Stomach contents from specimens of phalaropes, longspurs, and buntings collected periodically were examined to determine what insect populations were being exploited by these birds.

Results

1) Invertebrates from the top ten centimeters (Berlese samples) were obtained in greater quantity in 1952 than in 1953. In the former year, the period of largest overall samples extracted from the soil was in the first two weeks of July, whereas in 1953 there was no marked and sustained high abundance.
2) Surface insects became numerous in the period July 11-20 in both years. Again there were fewer in 1953 than in 1952. A rough approximation of the order of abundance in mid-July in the two years was 3:1.
3) The differences are believed to be the consequence of extensive reduction of herbaceous vegetation and exposure of the soil surface in the course of the winter 1952-53 by grazing activities of lemmings.
4) The period of peak abundance of insects comes about two weeks after the period when the populations of small song-birds (longspur and bunting) are making the greatest demands on the available food (that

is, in that period when young are in the nest). On the other hand, the period more or less coincides with that when precocial young of shore-birds are hatched and growing rapidly.

5) Virtually all insects are represented in the food consumed by phalaropes, longspurs, and buntings. The quantitative shifts in representation reflect availability of the common species.

6) As a by-product of this work on insect populations, Dr. Hurd accumulated a collection in excess of 500,000 specimens*, which are now deposited in the collections of the University of California, the United States National Museum, and other institutions. See appendix 3.

VII

VERTEBRATE FAUNA OF THE BARROW REGION

Problem

There is hardly a "problem" to be circumscribed by the heading given above. Rather our efforts in this department of our field activities are a by-product of work described in the first six sections. Out of a philosophy of methodology many field workers in biology have, we made it a point to record occurrences of birds and mammals of faunistic interest.

Beyond this, however, we did concern ourselves with a real problem; namely, what are the phenological characteristics (patterns of seasonal change) of an arctic avifauna? While much exploratory work has been done in northern Alaska as in other parts of the arctic to determine what species of animals are present, the information is scattered and qualitative, collected by persons who are more taxonomists and biogeographers than ecologists. The result is that for no arctic area known to us is there in the literature a compact picture of the characteristics of a local avifauna based on as many as three years of close study in the field. The year-to-year variation among species

* This figure is high because of the long series of mechanically collected Berlese samples.

in their relative numbers, not to mention their presence or absence, are poorly recorded for all but a few parts of the arctic (as sections of Greenland), and there is as yet no analysis from an ecological point of view of any one local avifauna. This we hope to provide for the Barrow area.

Results

1) Data on the avifauna we now have consists of note-book records of occurrence, of census sheets from population plots, of banding records, as well as data in the literature provided by previous students.

2) A total of 663 specimens of birds and 117 of mammals, prepared for deposit in museums have been placed in the collections of the Museum of Vertebrate Zoology and the United States National Msoum. These are listed in appendix 2. Annual reports on these collections have been submitted to the Juneau and Washington offices of the Fish and Wildlife Service.

3) This material has yet to be studied.

REPORTS AND PUBLICATIONS TO DATE

Technical reports

No final reports of a technical character have been published yet.

Published abstracts and short reports

1951. Banding activities on the arctic slope of Alaska. Bird-Banding, 22:181. (Pitelka and Childs)

1953. Population organization in arctic passerine birds. Proc. 2nd Alaskan Science Conference, 1951, p. 340. (Pitelka)

1954. "Myiasis" resulting from the use of the aspirator method in collection of insects. Science, in press. (Hurd)

Manuscripts

1. "The role of insects in the economy of certain arctic Alaskan birds," submitted for publication in the Proceedings of the 3rd Alaskan Science Conference. (Hurd and Pitelka)

2. "Composition of the insect fauna at Point Barrow, Alaska," to be submitted for publication; presented before the Pacific Coast Entomological Society, February, 1954. (Hurd)

3. "Population trends in avian predators near Barrow, Alaska, 1951-53," to be submitted for publication. (Pitelka, Tomich, and Treichel)

4. "Observations on behavior of jaegers and owls near Barrow, Alaska," to be submitted for publication. (Pitelka, Tomich, and Treichel)

5. "Lemmings and their predators at Point Barrow, Alaska, in 1951-52," presented before the Western Naturalists Society, Portland, Oregon, December, 1952. (Pitelka)
(See page v of "Current Biological Research in the Alaskan Arctic," 1953, Stanford University Press.)

Short reports

Lists of specimens collected were submitted annually to the Fish and Wildlife Service.

Lists of birds banded were submitted annually to the Fish and Wildlife Service and the Western Bird-Banding Association.

Monthly progress reports and annual summary reports were submitted to the ONR and SDARL.

Papers presented at scientific meetings

"Molt in passerine birds at Point Barrow, Alaska," presented before the American Ornithologists' Union, Montreal, October, 1951. (Pitelka)

"The daily activity cycle in arctic birds," presented before the Cooper Ornithological Society, San Francisco, May, 1952. (Pitelka)

"Avian predators in the lemming cycle near Barrow, Alaska," presented before the American Ornithologists Union, Los Angeles, October, 1953. (Pitelka)

See also 2 and 5 above, under manuscripts.

Papers being prepared for publication

"A new multiple-catch bird-trap," by Hurd and Childs.

"Case report of nasal myiasis," by Donald G. Castorlino, M.D., Berkeley, ms to be submitted to *California Monthly Medicine*.

KNOWN OR POTENTIAL APPLICATIONS OF RESULTS

This section should be distinguished by its brevity, if nothing else. The bulk of the results of our investigation is of basic interest to biologists and is of little practical interest to the government, at least at present. What knowledge has been gained about populations of land vertebrates

might be of interest in an appraisal of upland food resources, but there is no prospect at present that such an appraisal will be needed.

The fact remains, however, that through the support extended by the Office of Naval Research and the Arctic Institute of North America, a substantial quantity of new information concerning arctic land vertebrates and arctic conditions has been collected, and first-hand acquaintance with arctic conditions (May-September) has been acquired by eight men. Research in the field and the thinking of the participants has been focused on basic problems of population ecology, and whether in the arctic or elsewhere, the results should be of value both to theory in that field and to formulations concerning conservation practice.

RECOMMENDATIONS FOR FUTURE WORK

The all-pervading effects of the lemming cycle are such that this phenomenon, central in the ecology of arctic coastal plains as those near Barrow, should receive much more attention in the future. The impact of lemmings on vegetation and on surface characteristics of the soil in various habitats particularly deserve close study. Such study should be carried out intensively in one area, certainly over the period of one lemming cycle (four or five years).

Particularly striking in our experience near Barrow in 1952 and 1953 was the evidence on extensive effects of lemmings on microtopography. Because of the relevance of this fact to studies of permafrost phenomena, and of the development of local erosion and drainage patterns, the relation of the activities of lemmings to surface soil characteristics should be investigated intensively.

Further work on the lemming cycle is also desirable for its interest to theories of population ecology. A leading ecologist (Solomon) stated in a recent review that the question of whether periodic fluctuations in natural populations can be self-promoting is probably to be worked out in the arctic,

if at all in natural situations. This view is based on the fact that the arctic faunas are simple in structure and the record of population fluctuations shows them to be remarkably regular as well as violet, not to mention that the cycles are only 3-4 years long, on the average.

The problem of population fluctuations is of course an important one not only in the biology of various common animals other than man, but in the biology of man himself. The importance of appraising ecological phenomena on the population level has been emphasized in a recent symposium issue of Human Biology.

In other words, lemming cycles, all their facets and all their manifestations, deserve much, much more study in the field. As information collected in northern Alaska in the last five years, by various research groups, becomes available for critical consideration, and as similar work is reported from Canadian and other sectors of the arctic, it should be possible to formulate programs for future work with the preciseness satisfying the best standards in research.

With regard to studies on arctic land vertebrates in general, virtually any phase of reproductive biology and environmental control promises interested results if the investigations are conducted in an intensive, well-circumscribed method. This optimism results from the fact that the limited summer period, the low temperatures, and the continuous light prevailing in the arctic provide special, in effect experimental, conditions in the field. The results of any studies on the relations of these conditions to the breeding cycles and population performances of various arctic species are certain to provide valuable information because of the interest generated by the large accumulation of field and experimental results at mid-latitudes.

ACKNOWLEDGEMENTS

Whatever values lie in the results of this research program derive from the excellent conditions and opportunities for efficient work provided by the Arctic Research Laboratory. To any biologist whose primary interests in research lie in field work, the advantages available at such a laboratory, at an out-of-way locality, are truly remarkable. The former director, Dr. Ira L. Wiggins, was generous and helpful to our group in all ways, and our work proceeded well because of his sustained and enthusiastic interest. This investigation was also assisted by the following persons and agencies, to whom we express our appreciation: Dr. Louis O. Quam and the Office of Naval Research, Washington, D.C.; Dr. H. J. Carlson and Mr. E. G. Keith of the ONR's San Francisco office; Col. Walter A. Wood and Mr. L. O. Colbert of the Arctic Institute of North America; Dr. Alden H. Miller, Director of the Museum of Vertebrate Zoology, University of California; Dr. E. G. Linsley, Chairman of the Department of Entomology, University of California, Berkeley; and Mr. H. S. Thomson, Assistant Business Manager, University of California, Berkeley.

Persons who participated in this research program are listed in appendix 4. The assistance provided by my co-workers was particularly valuable because of their advanced training and personal experience in research; and I realized many times that because of this my job of organizing and promoting work programs was greatly simplified. No statement here can fully express my appreciation to them.

Frank A. Pitelka

Berkeley, California
February 5, 1954

Appendix 1

LIST OF BIRDS BANDED NEAR BARROW, ALASKA

Species	1951	1952	1953	Totals
Lapland Longspur	229	445	729	1403
Snow Bunting	429	556	332	1317
Others:				
Hoary Redpoll	0	30	0	30
Tree Sparrow	1	2	2	5
White-crowned Sparrow	0	0	2	2
Fox Sparrow	0	0	3	3
Savannah Sparrow	0	2	0	2
Yellow Wagtail	0	1	0	1
Ruddy Turnstone	1	6	0	7
Golden Plover	5	1	0	6
Semipalmated Sandpiper	8	3	1	12
Red-backed Sandpiper	23	3	6	32
Baird Sandpiper	35	10	1	46
Red Phalarope	8	2	0	10
Arctic Tern	21	0	0	21
Pomarine Jaeger	0	20	0	20
Old-squaw	1	0	0	1
Totals	761	1081	1076	2918

Appendix 2

LIST OF SPECIMENS PREPARED AS SKINS OR SKELETONS AND DEPOSITED IN THE MUSEUM OF VERTEBRATE ZOOLOGY, UNIVERSITY OF CALIFORNIA, OR THE UNITED STATES NATIONAL MUSEUM, WASHINGTON, D.C.

Collected primarily near Barrow, Alaska; some collected at Umiat (Colville River), East Oumalik (114 mi. SSE Barrow), Inaru River (25 mi. S Barrow), Chandler Lake, Bettles, and Point Lay.

Species		1951	1952	1953	Totals
(1) BIRDS					
Yellow-billed Loon	Gavia adamsi	0	0	1	1
Pacific Loon	Gavia arctica	1	0	0	1
Red-throated Loon	Gavia stellata	2	0	1	3
Whistling Swan	Cygnus columbianus	1	0	0	1
Snow Goose	Chen hyperborea	1	0	0	1
Old-squaw	Clangula hyemalis	4	0	0	4
Steller Eider	Polysticta stelleri	6	0	5	11
King Eider	Somateria spectabilis	10	1	1	12
Pacific Eider	Somateria mollisima	5	0	0	5
Spectacled Eider	Arctonetta fischeri	1	0	4	5
Spruce Grouse	Canachites canadensis	1	0	0	1
Willow Ptarmigan	Lagopus lagopus	15	1	1	15
Semipalmated Plover	Charadrius semipalmatus	2	0	0	2
Golden Plover	Pluvialis dominica	8	2	0	10
Black-bellied Plover	Squatarola squatarola	1	0	0	1
Ruddy Turnstone	Arenaria interpres	6	0	1	7
Wilson Snipe	Capella gallinago	1	0	0	1
Solitary Sandpiper	Tringa solitaria	1	0	0	1
Pectoral Sandpiper	Erolia melanotos	17	3	1	21
White-rumped Sandpiper	Erolia fuscicollis	1	0	0	1
Baird Sandpiper	Erolia bairdii	15	2	3	20
Red-backed Sandpiper	Erolia alpina	15	2	3	20
Long-billed Dowitcher	Limnodromus scolopaceus	7	0	2	9
Semipalmated Sandpiper	Ereunetes pusillus	9	0	0	9
Buff-breasted Sandpiper	Tryngites subruficollis	7	0	0	7
Bar-tailed Godwit	Limosa lapponica	4	1	0	5
Sanderling	Crocethia alba	2	0	0	2
Red Phalarope	Phalaropus fulicarius	23	7	6	36
Northern Phalarope	Lobipes lobatus	5	0	0	5
Pomarine Jaeger	Stercorarius pomarinus	0	8	4	12
Parasitic Jaeger	Stercorarius parasiticus	4	0	0	4
Long-tailed Jaeger	Stercorarius longicaudus	10	0	1	11

Species		1951	1952	1953	Totals
Glaucous Gull	Larus hyperboreus	8	0	0	8
Herring Gull	Larus argentatus	1	0	0	1
Ross Gull	Rhodostethia rosea	0	0	2	2
Sabine Gull	Xema sabini	14	0	1	15
Kittiwake	Rissa tridactyla	3	0	0	3
Arctic Tern	Sterna paradisea	12	0	6	18
Murre	Uria lomvia	0	0	1	1
Tufted Puffin	Lunda cirrhata	2	0	0	2
Snowy Owl	Nyctea scandiaca	1	1	4	6
Short-eared Owl	Asio flammeus	0	0	5	5
Horned Lark	Eremophila alpestris	0	1	0	1
Bank Swallow	Riparia riparia	0	0	1	1
Robin	Turdus migratorius	0	1	0	1
Wheatear	Oenanthe oenanthe	1	0	2	3
Red-spotted Bluethroat	Cyanosylvia suecica	4	0	0	4
Willow Warbler	Phylloscopus borealis	6	2	0	8
American Pipit	Anthus spinoletta	0	1	2	3
Yellow Wagtail	Motacilla flava	13	0	0	13
Chinese Mountain Hedge Sparrow	Prunella montanella	0	1	0	1
Myrtle Warbler	Dendroica coronata	0	0	1	1
Wilson Warbler	Wilsonia pusilla	0	1	0	1
Cowbird	Molothrus ater	1	0	0	1
Hornemann Redpoll	Acanthis hornemanni	12	3	1	16
Savannah Sparrow	Passerculus sandwichensis	7	1	0	8
Slate-colored Junco	Junco hyemalis	0	0	1	1
Tree Sparrow	Spizella arborea	9	2	1	12
White-crowned Sparrow	Zonotrichia leucophrys	2	1	1	4
Fox Sparrow	Passerella iliaca	0	1	1	2
Lapland Longspur	Calcarius lapponicus	81	58	5	144
Snow Bunting	Plectrophenax nivalis	50	73	10	133
Totals		412	173	78	663

(2) <u>MAMMALS</u>

Arctic Fox	Alopex lagopus	3	0	1	4
Red Fox	Vulpes fulva	0	1	0	1
Ground Squirrel	Citellus parryi	9	0	0	9
Shrew	Sorex (obscurus?)	1	0	1	2
Meadow Mouse	Microtus (spp.)	27	0	0	27
Brown Lemming	Lemmus trimucronatus	4	9	35	48
Collared Lemming	Dicrostonyx groenlandicus	5	1	6	12
Short-tailed Weasel	Mustela ermin	0	0	1	1
Least Weasel	Mustela rixosa	0	0	13	13
Totals		49	11	57	117

Appendix 3

SUMMARY OF INSECT COLLECTIONS OBTAINED NEAR BARROW, ALASKA

Order	Number of families	Number of species	Specimens Pinned	Specimens Alcoholic
Collembola	9	15 +		---*
Plecoptera	1	1		±50
Mallophaga	3	6		±50
Anoplura	2	3		10
Thysanoptera	1	1		±20
Hemiptera	2	2	53#	Few
Coleoptera	4	8	449#	Developmental stages
Trichoptera	1	2	57#	±150
Lepidoptera	2	2	26#	---
Diptera	20 +	75 +	4505#	21 vials
Hymenoptera	6	40 +	851#	± 10 vials
	50 +	150 +	5940	? ? **

* Bulk of these makes estimate of totals futile. Specimens now being sorted.

** Included with alcoholic specimens are a large number of mites (Arachnida) now under study by Dr. Robert E. Beer, Department of Entomology, University of Kansas.

\# Specimens sent to the United States National Museum for identification and disposition. A portion is to go to the Canadian National Museum, another portion is to be returned to the Department of Entomology, University of California, Berkeley.

Appendix 4

PERSONNEL OF THIS RESEARCH PROGRAM

Name	Summer period at Barrow	Present address
Henry E. Childs, Jr.	1951	San Joaquin Experimental Range O'Neals, California
Dr. Keith L. Dixon	1952	Department of Wildlife Management Texas A and M College College Station, Texas
William W. Dunmire	(Research assistant at Berkeley, '52-'53 and '53-'54)	Museum of Vertebrate Zoology University of California Berkeley 4, California
Gilbert S. Greenwald	1951	Museum of Vertebrate Zoology
Elmer B. Harvey	(Prepared histological materials at Berkeley, '52-'53)	Department of Zoology University of California Davis, California
Dr. Paul D. Hurd	1952-1953	Department of Entomology University of California Berkeley 4, California
Dr. Frank A. Pitelka	1951-1953	Museum of Vertebrate Zoology
William L. Thompson	1953	Museum of Vertebrate Zoology
P. Quentin Tomich	1953	Department of Zoology University of California Davis, California
George W. Treichel	1952	Department of Geography University of California Berkeley 4, California

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